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AN ASSESSMENT OF THE NEBRASKA CITY POWER STATION IMPINGEMENT EFFECTS RELATIVE TO THE FISHERY DYNAMICS OF THE MISSOURI RIVER

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Pursuant to National Pollutant Discharge Elimination System (NPDES) Permit No. NE 0111635, the Omaha Public Power District conducted an environmental monitoring program at the Nebraska City station. This study was undertaken to assess the effects of the station's cooling-water intake structure upon the aquatic biota of the Missouri River as required by Section 316(b) of the Federal Water Pollution Control Act. It included a study of fishes impinged on the intake structure's six traveling screens. From 29 May 1979 to 31 May 1982, daily fish impingement sampling occurred at 1200 and 2400 ± 2 hr. One of the traveling screens, in sequence, was sampled for 1 hr. A total of 1,508 fishes was impinged during daily sampling. These fishes included *Osmerus mordax* (36.1%), *Carpiodes carpio* (20.8%), *Ictalurus punctatus* (17.3%), and *Aplodinotus grunniens* (12.1%). The majority of these were age-class 0 ($\bar{x}$ length = 88 mm). The population of adult fishes in the vicinity of the station was sampled utilizing seining and electroshocking techniques. From October 1977 through December 1981, there were 17 sampling efforts utilizing the catch per unit effort procedure and 12 population estimates completed on a seasonal basis (spring, summer, and fall). This spectrum of fishery indicators points to fishery stability over long periods. Impingement is within compensatory capabilities of the fish population as shown by the stable population structure of adult fishes. In assessing effects of impingement, the controlled flow-regime of the Missouri River must be considered. Summer flows (ca 1,286 cms) are sufficient to provide abundant fishery spawning and nursery areas. The reduced flows (ca 571 cms) in the winter result in reduction of habitat that is combined with seasonal severity to limit over-wintering capability of the river's fishery. As a result, the summer fish production cannot be accommodated by the winter conditions of the river.

† † †

INTRODUCTION

A fisheries monitoring program was conducted at the Nebraska City station to satisfy Section 316(b) required by the Federal Water Pollution Control Act. The two-part program consisted of a River Fishery Monitoring Program (RFMP) and an Intake Structure Impingement Monitoring Program (ISIMP). The RFMP component was conducted from the fall of 1977 through the spring of 1982. The ISIMP was conducted from the initial date of commercial plant operations, 29 May 1979, through 31 May 1982. These programs were conducted to evaluate the influence of impingement upon the population of adult fishes in the vicinity of the Nebraska City station.

Common and scientific names, according to Robins et al. (1980), of fishes collected during this study are as follows:

Acipenseridae (sturgeons)	
Scaphirhynchus platorynchus	Shovelnose sturgeon
Anguillidae (freshwater eels)	
Anguilla rostrata	American eel
Catostomidae (suckers)	
Carpiodes carpio	River carpsucker
C. cyprinus	Quillback
Catostomus commersoni	White sucker
Cycleptus elongatus	Blue sucker
Ictiobus bubalus	Smallmouth buffalo
I. cyprinellus	Bigmouth buffalo
I. niger	Black buffalo
Moxostoma macrolepidotum	Shorthead redhorse
Centrarchidae (sunfishes)	
Lepomis cyanellus	Green sunfish
L. humilis	Orangespotted sunfish
L. macrochirus	Bluegill
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie
P. nigromaculatus	Black crappie

Clupeidae (herrings)	
Alosa chrysochloris	Skipjack herring
Dorosoma cepedianum	Gizzard shad
Cyprinidae (minnows and carps)	
Carassius auratus	Goldfish
Ctenopharyngodon idella	Grass carp
Cyprinus carpio	Carp
Hybognathus nuchalis	Silvery minnow
H. placitus	Plains minnow
Hybopsis aestivalis	Speckled chub
H. gelida	Sturgeon chub
H. gracilis	Flathead chub
H. meeki	Sicklefin chub
H. storeriana	Silver chub
Notropis atherinoides	Emerald shiner
N. blennius	River shiner
N. dorsalis	Bigmouth shiner
N. lutrensis	Red shiner
N. stramineus	Sand shiner
Phenacobius mirabilis	Suckermouth minnow
Pimephales promelas	Fathead minnow
Semotilus atromaculatus	Creek chub
Esocidae (pikes)	
Esox lucius	Northern pike
Gadidae (codfishes)	
Lota lota	Burbot
Hiodontidae (mooneyes)	
Hiodon alosoides	Goldeye
Ictaluridae (freshwater catfishes)	
Ictalurus melas	Black bullhead
I. punctatus	Channel catfish
Noturus flavus	Stonecat
Pylodictus olivaris	Flathead catfish
Lepisosteidae (gars)	
Lepisosteus osseus	Longnose gar
L. platostomus	Shortnose gar
Osmeridae (smelts)	
Osmerus mordax	Rainbow smelt
Percichthyidae (temperate basses)	
Morone chrysops	White bass
Percidae (perches)	
Perca flavescens	Yellow perch
Stizostedion canadense	Sauger
S. vitreum vitreum	Walleye
Petromyzontidae (lampreys)	
Ichthyomyzon unicuspis	Silver lamprey
Polyodontidae (paddlefishes)	
Polyodon spathula	Paddlefish
Salmonidae (trouts)	
Salmo trutta	Brown trout
Sciaenidae (drums)	
Aplodinotus grunniens	Freshwater drum

MATERIALS AND METHODS

Fish Impingement

ISIMP studies were conducted from 29 May 1979 through 31 May 1982. Diurnal and noctural sampling occurred at noon and midnight ± 2 hr. When increased impingement-rates occurred, supplemental 24-hr monitoring studies were initiated. On nine separate occasions 24-hr impingement-monitoring was conducted 1 November 1979 through 14 March 1981.

Impinged fishes and non-fish fauna were removed manually from one of the intake structure's six traveling screens for a 1-hr period each sampling interval. A sequential approach was utilized to assure that all screens were sampled an equal number of times. During the first six 24-hr monitoring studies, all operational screens were sampled simultaneously for 15 min every 105 min. The three remaining studies consisted of sampling all operational screens concurrently for 30 min every 90 min. Sampled screens were operated continuously during the 24-hr monitoring studies.

The physical condition of impinged fishes was determined by placing them into a swim tank to be observed for swimming and opercular movements. Presence of these movements categorized fish as living while the absence of these movements categorized fish as dead. Non-fish of the sample were observed for any movement to be classified as living specimens.

Adult Fishery

Four sample locations were established in a 3.7 km river reach of the Missouri River adjacent to the Nebraska City station (Fig. 1). These areas were located on both sides of the river above and below the plant site.

Location 1 is on the Nebraska bank and extends approximately 1.6 km upstream from the plant's intake. It includes

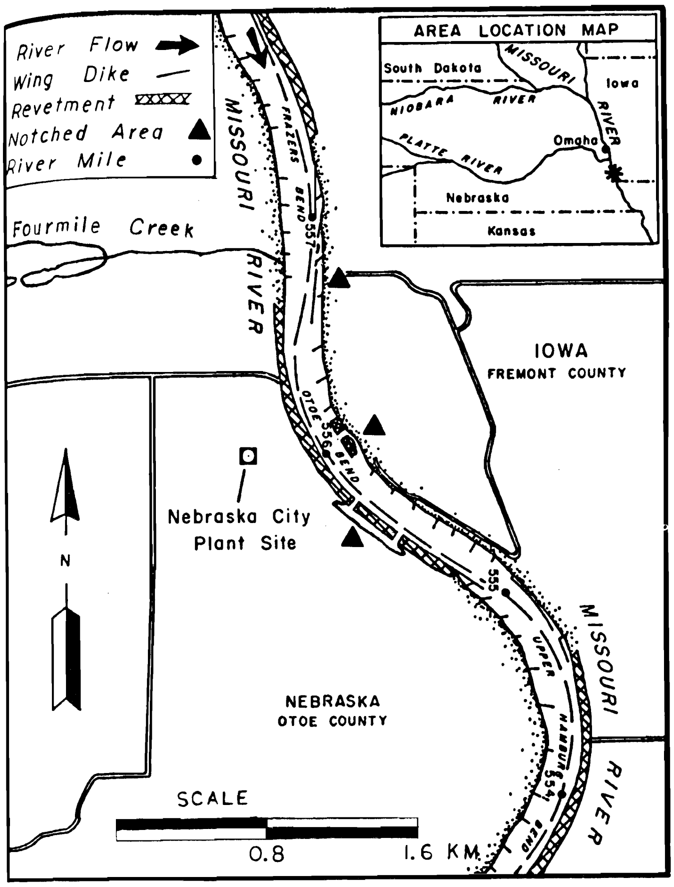

FIGURE 1. Sampling locations and habitat in the vicinity of the Nebraska City, Nebraska, station. Upstream location extends from RM 556.2 to 557.2 and the downstream location from RM 554.9 to 556.2.

approximately 610 meters of rock-revetment and is characterized by a swift current and a scoured bottom. Several wing dikes are also included in this area. They are characterized by swift current upstream and off the end of the dike with calmer water downstream.

Location 2 is on the Nebraska bank and extends approximately 1.6 km downstream from the plant intake. It is characterized primarily by rock-revetment. Several wing dikes are also included in this location.

Location 3 is on the Iowa bank and extends approximately 1.6 km upstream of the plant site. It consists of rock-revetment, notched revetments, and wing dike areas.

Location 4 extends approximately 1.6 km downstream of the plant intake on the Iowa bank and includes notched revetments and wing dike areas.

The primary method of collection was pulsed direct current (D.C.) electroshocking, using a 5.5 meter flatbottom boat with a front mounted boom and electrodes. A variable voltage pulsator was used on all collection dates.

Catch per unit of effort (CPE) was used to establish species composition and relative abundance of fishes in the area. CPE is defined as the number collected during 30 min of electroshocking. After each period of electroshocking, fishes collected were identified, weighed (grams), and measured (total length in millimeters) in the field and then released. To supplement the CPE data, two seine hauls per sample location were made when river conditions permitted, using a 7.6 x 1.2 meter, 0.01 meter mesh bag seine. This method of collection permitted the sampling of minnows and young-of-the-year (YOY) fishes. Fishes collected from seine hauls were transferred immediately to sample jars containing 5% formalin for later identification.

The protocol for estimating the population of fishes requires that approximately 1,200 be collected. Sampling was confined to approximately 1.6 km above and below the plant site on both sides of the river. Fishes 100 mm and larger were collected for the population estimate. Fishes collected for the population estimate were identified and representative individuals were weighed (grams) and measured (millimeters). Scales were taken from fishes of selected species to establish age-class composition of the population. Fishes were grouped into 25 mm intervals, with seven fish per species per size-group being aged. Scale impressions were made on plastic slides, using a scale press, and read with the aid of a microprojector.

Fishes collected upstream were marked with an upper caudal clip whereas those collected downstream were marked with a lower caudal clip. This was done to establish movements between locations. As indicated previously, the marking segment normally required approximately 1,200 fishes, which usually required three or four days of sampling. The recapture segment also required approximately 1,200 to be captured. The number of fishes to be marked and examined for marks was established from tables provided by Robson and Reiger (1964). It was decided, by analysis of the results, that movement between upstream and downstream locations greater than approximately 16% invalidated estimates of population.

Chapman's modification of the Petersen Population Estimation Method as described by Ricker (1975) was used to estimate the size of the population in the vicinity of the Nebraska City station. Seber (1973) delineated the following assumptions that must be fulfilled to obtain a reasonably accurate estimate:

1. The population is "closed" (where "closed" is defined as a population that remains unchanged during the

period of investigation with the effects of migration, mortality, and recruitment being negligible).

2. All have the same probability of being caught in the first sample.

3. Marking does not affect the catchability.

4. The second sample is a simple random one such that each of the possible samples has an equal chance of being collected.

5. Marks are not lost in the time between two sample collections.

6. All marks are reported on recovery on the second sample.

Assuming that the proportion of marked fishes in the second sample is a reasonable estimate of the unknown population, the following formula is used:

$$N = \frac{(M+1)(C+1)}{R+1}$$

Where: N = Population, M = Number marked, C = Number in the recapture sample, and R = Number of marked in the recapture sample.

Chapman (1948) and Seber (1973) recommend pooling the data as opposed to reporting individual species when a low recapture rate is experienced. This approach was used here. Since catfish, shovelnose sturgeon, and paddlefish are not readily susceptible to collection by D.C. electroshocking, fishes of these species were excluded from the estimates with the exception of flathead catfish which were only included in the summer estimates.

The confidence interval (C.I.) for the estimate was set at the 95% level of confidence and determined by the equation: C.I. = $1.96\sqrt{V(N)}$. The variance of the estimate was determined by:

$$V(N) = \frac{M^2(C+1)(C-R)}{(R+1)^2(R+2)}; \quad V(N) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}$$

as described by Ricker (1958) and Seber (1973), respectively.

RESULTS AND DISCUSSION

Fish Impingement

A total of 1,508 fishes, representing 31 species, was impinged during the routine sampling intervals (Table I). Fishes more commonly impinged included rainbow smelt (36.1%), river carpsucker (20.8%), channel catfish (17.3%), and freshwater drum (12.1%). These fishes comprised 86.3% of those

TABLE I. Species composition, relative abundance, mean length, and mean weight of fishes impinged during diurnal and nocturnal sampling at the Nebraska City station 29 May 1979–31 May 1982.

Fish	Number Impinged	Relative (%) Abundance	$\bar{x}$ Length (mm)	$\bar{x}$ Weight (g)
Rainbow smelt	545	36.1	76	2.8
River carpsucker	313	20.8	104	39.5
Channel catfish	261	17.3	90	27.8
Freshwater drum	183	12.1	86	13.8
Flathead catfish	30	2.0	92	26.6
Gizzard shad	23	1.5	134	29.1
Black bullhead	19	1.3	118	42.4
White bass	16	1.1	110	20.0
Silver chub	15	1.0	90	12.1
Bluegill	10	0.7	64	9.1
Stonecat	10	0.7	99	26.9
Sicklefin chub*	10	0.5	101	8.8
Carp	6	0.4	109	62.1
White crappie	6	0.4	90	104.7
Green sunfish	3	0.2	57	18.0
Shortnose gar	3	0.2	517	454.5
Black crappie	3	0.2	61	6.0
Shovelnose sturgeon	2	0.1	306	152.5
Sauger	2	0.1	233	105.0
Creek chub	2	0.1	125	21.0
Red shiner	2	0.1	54	2.0
Suckermouth minnow	2	0.1	85	7.5
Emerald shiner	2	0.1	84	3.5
Sturgeon chub*	2	0.1	101	10.0
Largemouth bass	2	0.1	113	21.0
Fathead minnow	2	0.1	60	1.5
Orangespotted sunfish	2	0.1	65	5.5
Longnose gar	1	0.1	900	1,500.0
Sand shiner	1	0.1	63	3.0
Goldfish	1	0.1	135	56.0
Plains minnow	1	0.1	60	3.0
Unavailable†	31	2.1	-----	-----
TOTAL	1,508	100.0	$\bar{x}$= 88	$\bar{x}$= 21.3

*Uncommon indigenous species in Nebraska.

†Samples misplaced.

impinged during the 37-month study period and represented 63.4% to 89.7% of each annual impingement. The range of mean lengths for fishes of the four most frequent species was 76 to 104 mm, averaging 88 mm. Fishes in this size category are usually young-of-the-year (YOY). Game and commercial fishes averaged 36.0% of those impinged over the entire study period.

At the conclusion of the 24-hr monitoring studies, 1,218 fishes representing 20 species had been collected from the traveling screens (Table II; Fig. 2). Fishes commonly impinged included rainbow smelt (47.5%), gizzard shad (23.2%), freshwater drum (8.9%), channel catfish (7.6%), and river carpsucker (6.3%). Fishes of these species represented 93.8% of those impinged during the nine 24-hr sampling endeavors. The range of mean lengths for these fishes was 76 to 129 mm, averaging 93 mm. Game and commercial fishes comprised 27.4% of those collected. There was no federally listed threatened or endangered species impinged (Anonymous, 1980).

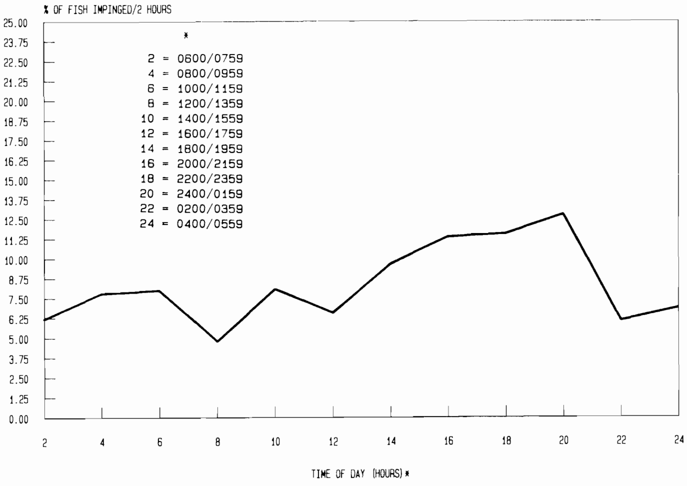

FIGURE 2. Nebraska City station diel pattern of fish impingement based on the nine combined 24-hour impingement periods.

TABLE II. Species composition and relative abundance of fishes impinged during the combined 24-hour sampling periods at the Nebraska City station 1 November 1979–14 March 1981.

Fish	1979 No.	1979 %	1980 No.	1980 %	1981 No.	1981 %	1979–1981 No.	1979–1981 %
Black bullhead	8	1.1	3	0.7	—	—	11	0.9
Bluegill	—	—	1	0.2	—	—	1	0.1
Channel catfish	30	4.0	63	14.5	—	—	93	7.6
Emerald shiner	—	—	2	0.5	—	—	2	0.2
Flathead catfish	13	1.7	17	3.9	—	—	30	2.5
Freshwater drum	63	8.3	46	10.6	—	—	109	8.9
Gizzard shad	269	35.5	13	3.0	—	—	282	23.2
Green sunfish	2	0.3	—	—	—	—	2	0.2
Johnny darter	1	0.1	—	—	—	—	1	0.1
Rainbow smelt	316	41.7	254	58.7	8	29.6	578	47.5
River carpsucker	35	4.6	23	5.3	19	70.4	77	6.3
Sand shiner	—	—	1	0.2	—	—	1	0.1
Shortnose gar	—	—	1	0.2	—	—	1	0.1
Shovelnose sturgeon	—	—	1	0.2	—	—	1	0.1
Sicklefin chub*	1	0.1	2	0.5	—	—	3	0.2
Silver chub	8	1.1	—	—	—	—	8	0.7
Sturgeon chub	2	0.3	—	—	—	—	2	0.2
Suckermouth minnow	—	—	1	0.2	—	—	1	0.1
White bass	9	1.2	2	0.5	—	—	11	0.9
White crappie	1	0.1	2	0.5	—	—	3	0.2
Unidentified minnow	—	—	1	0.2	—	—	1	0.1
TOTAL	758	100	433	100	27	100	1,218	100

*Uncommon indigenous species in Nebraska.

However, two sturgeon chubs and seven sicklefin chubs were collected, which are classified as uncommon indigenous species in Nebraska (Morris et al., 1974) and endangered in Iowa (Roosa, 1977).

At the termination of the 37-mo study, 26.9% of all impinged fishes were dead and 73.1% were alive. This overall ratio was representative of each annual live/dead impingement ratio.

Twelve animals other than fishes were impinged during routine sampling: five crayfish, four tadpoles, two tree frogs (*Pseudacris nigrita*), and one leopard frog (*Rana pipiens*).

Impingement rates were not constant, but varied seasonally, diurnally, and nocturnally (Fig. 3). Over the 37-mo study, 64.2% of the fishes were impinged nocturnally and the nocturnal mean impingement rate was 0.86 fish/hour/screen. The remaining 35.8% of the impinged fishes were impinged diurnally when the mean impingement rate was 0.49 fish/hour/screen. Seasonally, impingement rates were lower during the spring and summer months and showed an increase in the fall and winter months (Fig. 3).

Impingement Rates and Their Extrapolation

Impingement rates at the Nebraska City station demonstrated seasonal variability with the greatest rates in the fall and winter months. Several factors contributed to this occurrence. Summer river flows of 1,143 to 1,286 cms are reduced

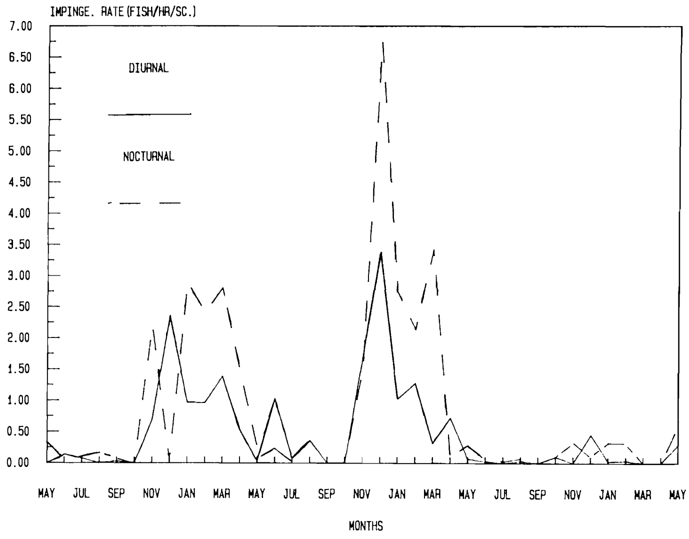

FIGURE 3. Nebraska City station fish impingement rate for May 1979–May 1982.

to 571 to 714 cms in the fall. This decrease in flow lowers the surface elevation of the river. As elevation decreases, nursery habitats are reduced, forcing juvenile fishes into the main channel of the river, where they became vulnerable to impingement. Reduced swimming ability due to low water temperatures may have also contributed to higher impingement rates of juvenile fish during this period. Water that is drawn in at the intake has a slightly higher velocity, due to the lower elevation of the river, and may have also contributed to higher rates of impingement (increases from 0.15 m/sec to 0.30 m/sec).

Due to the diurnal and nocturnal variation of impingement rate, the projected impingement loss was determined utilizing 24-hr monitoring data in conjunction with the data from regular sampling. Accumulated data from all the 24-hr studies were placed into 12 2-hr periods. As a result of evaluating the data in this manner, it was determined that 58.5% of the fishes were impinged during noctural periods (1800 hr–0559 hr), the remaining 41.5% being impinged during diurnal periods (0600 hr–1759 hr). The combined results (Table III) show that of the total diurnal impingement, 12.8% were impinged during the 1000–1400 hr routine sampling period. Hence, diurnal impingement extrapolations were calculated utilizing the following equation: The Average Daily Diurnal Fish Impingement (ADDFI) = Average Monthly Diurnal Impingement Rate X 13.0 X 4. The Average Monthly Diurnal Impingement Rate = the mean monthly number of fishes per hour per screen impinged between 1000 and 1400 hr; 13.0 is a conversion factor required to expand the diurnal impingement rate to the 12-hr diurnal period of 0600–1759 hr; (41.5/12.8) X 4 (routine sampling occurred 1 hr during the designated 4-hr time frame; hence, an expansion factor of 4 is required to calculate correctly the number impinged between 1000 and 1400 hr, which is represented by the 12.8% of the 24-hr total impingement); 4 = the number of traveling screens utilized in the intake structure.

The same format was followed for nocturnal extrapolations. Of the total impingement that occurred nocturnally, 24.5% occurred during the routine nocturnal sampling (2200–0200 hr). Therefore, the Average Daily Nocturnal Fish Impingement (ADNFI) = Average Monthly Nocturnal Impingement Rate X 9.6 X 4. The Average Monthly Nocturnal Impingement Rate = the mean monthly number of fishes per hour per screen impinged between 2200 and 0200 hr; 9.6 is a conversion factor required to expand the nocturnal impingement rate to the 12-hr nocturnal period of 1800–0559 hr; (58.5/24.5) X 4 (routine sampling occurred 1 hr during the designated 4-hr time frame, hence, an expansion factor of 4 is required to calculate correctly the number impinged between 2200 and 0200 hr, which is represented by the 24.5% of the 24-hr total impingement); 4 = the number of traveling screens utilized in the intake structure.

TABLE III. The number and percentage of fishes impinged in each of 12 two-hour time periods for all 24-hour monitoring studies conducted at the Nebraska City station 1 November 1979-14 March 1981.

	Time (Hours)	Expanded No. Impinged*	%
Diurnal	0600-0759	274	6.2
	0800-0959	346	7.8
	1000-1159	352	8.0
	1200-1359	212	4.8
	1400-1559	360	8.1
	1600-1759	292	6.1
Nocturnal	1800-1959	430	9.7
	2000-2159	502	11.4
	2200-2359	514	11.6
	2400-0159	568	12.8
	0200-0359	270	6.1
	0400-0559	304	6.9
	TOTAL	4,424	100.0

*Due to variance in the amount of collection time between 24-hr sample periods, adjustment in the number of fishes collected in each of the 12 two-hr time periods was required. This adjustment to the number collected put each of the nine 24-hr sampling periods on a common base. The adjustment was calculated as follows. (A) For those studies in which the screens were operated continuously and 15 min of sampling occurred every 105 min: Number of fishes impinged for all screens X Expansion factor of 4 = Total Intake Structure Impingement For One Hour. (B) For those studies in which the screens were operated continuously and 30 min of sampling occurred every 90 min: Number of fishes impinged for all screens X Expansion factor of 2 = Total Intake Structure Impingement For One Hour.

Hence, the total monthly impingement can be extrapolated by the summation of the ADDFI and the ADNFI multiplied by the days in the month the screens were in operation (Table IV). The equation is: (ADDFI + ADNFI) X Days of the month the screens were in operation = Total monthly fish impingement extrapolation. The projected total fish impingement for the 1,099-day study period is approximately 64,856.

Catch Per Unit Effort (CPE)

Seventeen sampling efforts were completed on a seasonal basis from October 1977 through December 1981. Eight were completed before commercial start-up of the station and nine after commercial start-up.

The mean CPE for electroshocking during the preoperational phase was 28 fishes compared to 38 fishes during the operational phase (Table V). The lower catch rates during the preoperational phase could be related to the high river flows (United States Army Corps of Engineers Daily River Bulletin 1977-1982, Missouri River Division, Omaha) in 1978, which influenced sampling efficiency.

Predominant fishes throughout the study period were carp, gizzard shad, goldeye, and river carpsucker (Table V). These four kinds of fishes were most abundant in collections and represented 84.7% of the D.C. electroshocker catch during the preoperational phase and 72.7% during the first three years of commercial operation. The lower relative abundance during the operational phase of the study could be related to river flow. During high river flow (preoperational), fewer species (17) were collected than during the operational phase (28). The reduced efficiency of electrofishing resulted from elevated river flow and caused relative abundance data to be skewed towards the most abundant species.

Seining was done in all four locations, when river conditions permitted. The mean catch/seine haul for the entire study was 20.1. Preoperationally, the catch rate was 19.7 and operationally it was 20.4 (Table VI). Preoperationally, emerald shiners, plains minnows, river shiners, and silvery minnows were the most abundant fishes collected representing 77.4% of the total. In comparison, during the sampling periods when the station was in operation, emerald, red, and river shiners were the most abundant fishes collected, representing 79.1% of the total. Species fluctuations between preoperational and operational portions of the study could be related to the higher river flows in 1978, which reduced habitat generally accessible for seining (Hesse et al., 1982; Pflieger, 1975).

Population Estimates

Population estimates were conducted on a seasonal basis (spring, summer, and fall) from November 1977 to April 1982 (Table VII). Twelve population estimates were completed during this period. Of these, five were not considered valid (spring 1978, 1979, and 1981; summer 1979; fall 1979) because much (16.2%) movement of fishes occurred between locations. Carp, flathead catfish, goldeye, and river carpsucker were the most often recaptured. Of these, carp and goldeye exhibited the most movement between locations. Movement was greatest in the spring followed by fall and summer respectively (Table VIII).

Two spring estimates considered valid were completed in 1980 and 1982. These estimates were 68,878 ± 27.9% (49,689-88,067) and 19,170 ± 29.9% (13,429-24,911) for the 3.7 km area respectively. This represented between

TABLE IV. Extrapolations of monthly fish impingement at Nebraska City.

Month	Average Diurnal Rate Monthly*	Daily†	Average Nocturnal Rate Monthly*	Daily†	Total Per 24 hr	Extrapolated Monthly Total
			1979			
May (29th–31st)	0	0	0.33	12.7	12.7	36
June	0.13	6.8	0.07	2.7	9.5	285
July	0.07	3.6	0.10	3.8	7.4	229
August	0	0	0.16	6.1	6.1	189
September	0.03	1.6	0.07	2.7	4.3	129
October	0	0	0	0	0	0
November	0.70	36.4	2.20	84.5	120.9	3,627
December	2.36	122.7	0.03	1.2	123.9	3,841
1979 TOTAL						7,910
			1980			
January	0.97	50.4	2.90	111.4	161.8	4,991
February	0.97	50.4	2.41	92.5	142.9	4,144
March	1.39	72.3	2.81	107.9	180.2	5,586
April	0.53	27.6	1.50	57.6	85.2	2,556
May	0.03	1.6	0.26	10.0	11.6	360
June	1.03	54.0	0.23	8.8	62.8	1,884
July	0.07	3.6	0.03	1.2	4.8	149
August	0.36	18.7	0.36	13.8	32.5	1,008
September‡						
October‡						
November	1.70	88.4	1.47	56.5	144.9	4,347
December	3.39	176.3	6.74	258.8	435.1	13,488
1980 TOTAL						38,513
			1981			
January	1.03	53.6	2.74	105.2	158.8	4,923
February	1.32	68.6	2.21	84.9	153.5	4,306
March	0.32	16.6	3.42	131.3	147.9	4,585
April	0.73	38.0	0.13	5.0	43.0	1,290
May	0.07	3.6	0.29	11.1	14.7	456
June	0.03	1.6	0.10	3.8	5.4	162
July	0	0	0.03	1.2	1.2	37
August	0	0	0.09	3.5	3.5	109
September‡						
October	0	0	0.09	3.5	3.5	109
November	0	0	0.17	6.5	6.5	195
December	0.26	13.5	0.09	3.5	17.0	527
1981 TOTAL						16,699
			1982			
January	0.03	1.6	0.19	7.3	8.9	276
February	0.04	2.1	0.07	2.7	4.8	134
March‡						
April‡						
May	0.32	16.6	0.68	26.1	42.8	1,324
1982 TOTAL						1,734
	$\bar{x} = 0.49$		$\bar{x} = 0.86$		GRAND TOTAL	64,856

*Number of fishes impinged per hour per screen.
†Number impinged 0600 to 1759 (diurnal) and 1800 to 0559 (nocturnal) as determined by equation.
‡Plant down.

TABLE V. Number and relative abundance of fishes collected at the Nebraska City station by electroshocking.

Fish	Number of Fish		Relative Abundance (%)		Number Per 30 Minutes	
	Preoperational	Operational	Preoperational	Operational	Preoperational	Operational
Carp	245	347	27.2	25.4	7.6	9.6
River carpsucker	205	201	22.8	14.7	6.4	5.6
Gizzard shad	164	237	18.2	17.3	5.1	6.6
Goldeye	149	209	16.5	15.3	4.6	5.8
White bass	23	11	2.6	0.8	0.7	0.3
Freshwater drum	44	36	4.9	2.6	1.4	1.0
Sauger	32	36	3.6	2.6	1.0	1.0
Emerald shiner	2	—	0.2	—	0.1	—
Bigmouth buffalo	2	16	0.2	1.2	0.1	0.4
Smallmouth buffalo	1	10	0.1	0.7	< 0.1	0.3
Flathead chub	1	—	0.1	—	< 0.1	—
Blue sucker	4	22	0.4	1.6	0.1	0.6
Channel catfish	7	14	0.8	1.0	0.2	0.4
Flathead catfish	4	149	0.4	10.9	0.1	4.1
Shortnose gar	6	23	0.7	1.7	0.2	0.6
Quillback	1	—	0.1	—	< 0.1	—
Black crappie	3	10	0.3	0.7	0.1	0.3
White crappie	5	15	0.6	1.1	0.2	0.4
Shorthead redhorse	2	8	0.2	0.6	0.2	0.2
Bluegill	1	1	0.1	0.1	< 0.1	< 0.1
Longnose gar	—	8	—	0.6	—	0.2
Shovelnose sturgeon	—	2	—	0.1	—	< 0.1
Northern pike	—	1	—	0.1	—	< 0.1
Largemouth bass	—	1	—	0.1	—	< 0.1
Skipjack herring	—	6	—	0.4	—	0.2
American eel	—	2	—	0.1	—	< 0.1
White sucker	—	1	—	0.1	—	< 0.1
Paddlefish	—	1	—	0.1	—	< 0.1
Grass carp	—	1	—	0.1	—	< 0.1
TOTAL	901	1,368			28.5	38.4

TABLE VI. Number and relative abundance of fishes collected at the Nebraska City station by seining.

Fish	Number of Fish		Relative Abundance (%)		Number Per 30 Minutes	
	Preoperational	Operational	Preoperational	Operational	Preoperational	Operational
Plains minnow	183	89	23.0	6.8	3.2	1.2
Silvery minnow	211	1	26.5	0.1	4.8	< 0.1
Silver chub	57	69	7.2	5.3	1.2	1.0
Emerald shiner	102	438	12.8	33.4	2.5	6.0
Channel catfish	17	10	2.1	0.7	0.4	0.1
White bass	5	1	0.6	0.1	0.1	< 0.1
Gizzard shad	3	—	0.4	—	0.1	0.0

TABLE VI. Continued.

Fish	Number of Fish		Relative Abundance (%)		Number Per 30 Minutes	
	Preoperational	Operational	Preoperational	Operational	Preoperational	Operational
River carpsucker	5	27	0.6	2.1	0.9	1.4
Red shiner	51	339	6.4	25.9	1.6	5.2
River shiner	120	260	15.1	19.8	3.0	3.8
Flathead chub	3	5	0.4	0.4	0.6	0.1
Sand shiner	12	17	1.3	1.3	0.4	0.2
Bigmouth shiner	9	11	0.8	0.8	0.3	0.2
Fathead minnow	4	7	0.5	0.5	0.1	0.1
Walleye	1	7	0.5	0.5	< 0.1	0.1
Speckled chub	1	13	1.0	1.0	< 0.1	0.2
Freshwater drum	2	1	0.1	0.1	< 0.1	< 0.1
Rainbow smelt	9	5	0.4	0.4	0.2	0.1
Suckermouth minnow	—	3	0.2	0.2	—	< 0.1
Sauger	—	6	—	0.5	—	0.1
Hybognathus sp.	—	1	—	0.1	—	< 0.1
Green sunfish	—	1	—	0.1	—	< 0.1
TOTAL	795	1,311			19.7	20.4

21,604 and 38,290 fishes in 1980 and 5,839 to 10,831 fishes in 1982 per 1.6 km of river. The difference in population size could be attributed to the reduction in the relative abundance of gizzard shad (29.3% in 1980 and 5.9% in 1982), probably due to a severe winter in 1981.

Valid population estimates for summer were completed in 1980 and 1981. Stable hydrologic conditions were experienced and little movement occurred between locations (3.3% and 7.0% in 1980 and 1981, respectively). Both are good estimates of summer population levels in the 1.6 km reach of the channelized Missouri River. The population estimates were 15,581 ± 18.7% (12,661-18,501) in 1980 and 11,894 ± 13.1% (10,340-13,448) in 1981. These estimates included flathead catfish. This represents between 5,505 and 8,044 in 1980 and 4,496 to 5,847 in 1981 per 1.6 km of river. An estimate of flathead catfish abundance was completed due to the success in collecting and resampling them. The population estimates were 2,886 ± 20.5% (2,295-3,477) in 1980 and 4,424 ± 13.2% (3,840-5,008) in 1981 per a 3.7 km sampling area. This represents 998 to 1,512 in 1980 and 1,670 to 2,177 in 1981 per 1.6 km of river. These estimates are considerably higher than those reported by Tondreau (1982) between River Marks 716.2 and 718.8.

Three population estimates from fall were considered to be valid (1977, 1980, and 1981). These estimates were 13,932 ± 18% (11,376-16,488) in 1977, 35,559 ± 36.7% (22,524-48,594) in 1980, and 27,265 ± 32.9% (18,283-36,247) in 1981. This represents between 4,946 and 7,169 in 1977, 15,460 to 21,128 in 1980, and 7,949 to 15,760 in 1981 per 1.6 km of river. The difference in population size could be attributed to the increase in abundance of gizzard shad in 1980 and 1981 (6.4% in 1977 to 26.8% in 1980 and 34.6% in 1981).

Hesse and Newcomb (1982) completed population estimates approximately 150 km upstream during the winters of 1979-1980 and 1980-1981. These estimates ranged from a mean of 1,870 fishes/km near Blair, Nebraska, in 1979-1980, but did not include channel catfish, to 13,087 fishes/km, which includes channel catfish, near Tekamah, Nebraska, in 1980-1981.

Information developed from population estimates has demonstrated the influence of the seasonality of fish movements upon estimating relative abundance. Climatic conditions, spawning behavior, river flow, and water temperature all are involved. These factors, when considered with the sampling bias for different age-classes, have shown the limited accuracy of spring, summer, and fall population estimates in the Missouri River.

TABLE VII. Summaries of estimates of the populations of adult fishes at Nebraska City from 1977 to 1982.

	1977 Relative Abundance	1978 Relative Abundance	1979 Relative Abundance	1980 Relative Abundance	1981 Relative Abundance	1982 Relative Abundance
SPRING						
		1. Goldeye 52.2%	1. Goldeye 35.4%	1. Gizzard shad 29.3%	1. Goldeye 34.2%	1. Goldeye 32.9%
		2. Carp 14.3%	2. Carp 20.3%	2. Goldeye 27.3%	2. Gizzard shad 29.8%	2. Carp 24.4%
		3. River carpsucker 13.2%	3. River carpsucker 14.1%	3. Carp 22.2%	3. Carp 16.1%	3. River carpsucker 18.5%
		4. Bigmouth buffalo 5.5%	4. Gizzard shad 9.6%	4. River carpsucker 7.8%	4. River carpsucker 7.5%	4. Freshwater drum 9.5%
		5. Freshwater drum 4.4%	5. Shortnose gar 4.7%	5. Shortnose gar 3.9%	5. Freshwater drum 6.2%	5. Gizzard shad 5.9%
Fishes collected		1,577	2,759	3,635	2,816	1,754
No. species		21	28	27	24	21
No. recaptured		24	21	45	32	37
Population estimate		22,787 ± 37.2%*	81,674 ± 40.2%*	68,878 ± 27.9%	56,580 ± 32.8%*	19,170 ± 29.9%
		14,320–31,254/3.7 km*	48,848–114,500/3.7 km*	49,689–88,067/3.7 km	38,028–75,132/3.7 km*	13,429–24,911/3.7 km
SUMMER						
		†	1. Carp 38.1%	1. Flathead catfish 35.8%	1. Flathead catfish 57.7%	
			2. Flathead catfish 17.6%	2. Carp 24.9%	2. Carp 16.4%	
			3. Goldeye 9.8%	3. Gizzard shad 13.2%	3. River carpsucker 5.5%	
			4. River carpsucker 6.4%	4. Goldeye 8.6%	4. Gizzard shad 5.0%	
			5. Gizzard shad 6.1%	5. River carpsucker 6.8%	5. Goldeye 4.3%	
			6. Freshwater drum 5.2%	6. Freshwater drum 2.4%	6. Blue sucker 3.1%	
Fishes collected			1,667	2,430	2,945	Fishes collected
No. species			25	24	19	No. species
No. recaptured			34	91	171	No. recaptured
Population estimate			18,054 ± 31.2%*	15,581 ± 18.7%	11,894 ± 13.1%	Population estimate
			12,423–23,685/3.7 km*	12,661–18,501/3.7 km	10,340–13,448/3.7 km	

TABLE VII. Continued.

1977 Relative Abundance	1978 Relative Abundance	1979 Relative Abundance	1980 Relative Abundance	1981 Relative Abundance	1982 Relative Abundance
			FALL		
1. River carpsucker 36.8%	†	1. River carpsucker 26.7%	1. Gizzard shad 26.8%	1. Gizzard shad 34.6%	
2. Carp 28.6%		2. Carp 22.8%	2. River carpsucker 20.4%	2. River carpsucker 28.9%	
3. Goldeye 14.5%		3. Gizzard shad 20.0%	3. Carp 15.4%	3. Carp 13.4%	
4. Gizzard shad 6.4%		4. Freshwater drum 8.6%	4. Freshwater drum 14.4%	4. Goldeye 8.2%	
5. Freshwater drum 5.0%		5. Goldeye 8.1%	5. Goldeye 10.7%	5. Freshwater drum 6.3%	
2,346		2,105	2,038	1,896	Fishes collected
22		25	23	16	No. species
94		50	25	31	No. recaptured
13,932 ± 18%		20,195 ± 26.1%*	35,559 ± 36.7%	27,265 ± 32.9%	Population estimate
11,376–16,488/3.7 km		14,929–25,463/3.7 km*	22,524–48,594/3.7 km	18,283–36,247/3.7 km	

*Population estimates not considered valid.

†No estimate completed due to high river flows.

TABLE VIII. Percentage movement between upstream and downstream locations for the seven most commonly recaptured kinds of fish during population estimates completed from 1977 to 1982.

Estimate	Flathead catfish		Carp		River carpsucker		Goldeye		Sauger		Gizzard shad		White crappie		All fish
	No. Recap.	% Movement	No. Recap.	% Movement	No. Recap.	% Movement	No. Recap.	% Movement	No. Recap.	% Movement	No. Recap.	% Movement	No. Recap.	% Movement	% Movement
Spring 1978*															
Spring 1979	0	0	8	25.0	3	0	2	100	1	0	0	0	1	0	33.3
Spring 1980	0	0	20	10.0	9	22.2	8	12.5	2	0	3	33.3	2	0	13.3
Spring 1981	0	0	13	15.4	2	0	7	57.1	1	0	6	33.3	3	66.7	31.3
Spring 1982	0	0	15	20.0	4	0	12	16.7	0	0	0	0	0	0	16.7
Spring mean		0		16.1		11.1		31.0		0		33.3		33.3	
Summer 1979	9	22.2	15	46.7	1	100	2	0	0	0	0	0	2	0	32.4
Summer 1980	64	1.6	21	9.5	2	0	1	0	0	0	0	0	2	0	3.3
Summer 1981	141	6.4	17	11.8	2	0	2	50.0	4	0	0	0	1	0	7.0
Summer mean		5.6		20.8		20.0		20.0		0		0		0	0
Fall 1977*															
Fall 1979	0	0	18	33.3	14	21.4	2	50.0	8	25.0	4	75.0	1	100	32.0
Fall 1980	0	0	7	0	4	25.0	1	0	3	66.7	4	25.0	4	0	16.0
Fall 1981	0	0	13	15.4	10	10.0	1	0	3	0	2	0	0	0	12.9
Fall mean		0		21.1		17.9		25.0		28.6		40.0		20.0	

*Raw data misplaced.

Species abundance was greatest during the spring with a range of 21 to 28 species being collected. Carp, gizzard shad, goldeye, and river carpsucker averaged 83.1% of the total collected; 79.7% preoperationally and 85.3% after the station became operational.

Species abundance during the summer ranged from 19 to 25. During this time, five fishes dominated: carp, flathead catfish, gizzard shad, goldeye, and river carpsucker. These fishes averaged 85.4% of the total. Due to high river flows in 1978, no preoperational summer estimates were completed. The large number of flathead catfish, found only in the summer, indicates a possible shift in habitat preference during this time, making them more susceptible to electroshocking.

Species abundance during the fall ranged from 16 to 25. Carp, freshwater drum, gizzard shad, goldeye, and river carpsucker accounted for 89.2% of all the fishes collected in fall population estimates; 91.3% of the total preoperationally and 88.4% during the operational portion of the study.

Age and Growth

A total of 3,567 fishes representing 19 species was aged during the entire study period. Carp, freshwater drum, goldeye, and river carpsucker were abundant throughout the study and represented 76.1% of the total aged. River carpsuckers were the most abundant in the spring and fall with a total of 704 being aged. Age-classes II and III were the most abundant both preoperationally and operationally (Table IX). Age-length relationships were similar to those reported by Hesse et al. (1978).

Carp in age-classes III, IV, and V were most abundant preoperationally and operationally (Table IX). The age-length relationship throughout the study period was similar to that found by Hesse et al. (1978), with the exception of a slower growth-rate of age-class I fish. Carp were abundant in all collections with 977 being aged.

A total of 453 freshwater drum was aged. The age-length relationship was similar preoperationally and operationally. Growth rates were faster, for all age classes, than reported by Pflieger (1975) in Missouri streams. Freshwater drum were most abundant in spring and fall with age-classes III and IV being most prevalent in the collections (Table IX).

The age-length relationship for goldeye was similar throughout the study except for age-class I. Mean lengths for age-class I were larger operationally than those collected preoperationally. Age-classes II, III, and IV were abundant with age class III being the most abundant (Table IX). Goldeye were dominant in spring collections. A total of 581 was aged.

The Use of Length Frequency Data to Evaluate Population Dynamics

Evaluation of length frequency was undertaken for two selected kinds of fishes, freshwater drum and river carpsucker. These two fishes were selected due to their high relative ranking in the impinged population and their high relative abundance in the fishery. Length frequency distribution of these fishes, through the years of study, is an indirect way to evaluate the impact of impingement on age-class. Age-class distribution was not determined directly because only seven fish per species in each 25 mm length-class were aged. Evaluation of the length frequency data (Table X) is best understood by placing it in context with the work of Hesse et al. (1982). They showed strong age-class dominance in river carpsucker that can persist for three or four years.

A somewhat different phenomenon occurred in the freshwater drum population. Table X demonstrates a consistent pattern in the low relative abundance of fish in the 200 mm range. In view of the fact that the length of the average impinged freshwater drum was 86 mm, and the relative abundance of fish 300 to 400 mm is stable, sampling bias due to habitat preference is suggested.

CONCLUSIONS

The extremely variable nature of the Missouri River must be considered when assessing the effects of impingement of fishes upon the river fishery. The river behaves very differently from year to year as well as seasonally. Climate in the drainage basin is volatile, and the controlled flow-regime of the river results in major fluctuations in stage and flow. Comparative studies face the reality that replicate years may not occur within any reasonable period. The intrinsic variability of the river provokes a secondary "diversity." Study plans fall prey to the natural variations. In the case of data gathering by means of electroshocking, for example, two successive spring seasons may exhibit such widely differing water levels at a given sample station that for the purposes of data interpretation the station simply cannot be thought of as being the same. Greatly different CPE's, for example, may reflect both real differences in fish mobility as well as changing susceptibility to the gear. Deciding how much of the variation to attribute to the "real" diversity of the river and how much to the resultant impact upon methodology is a basic problem faced by the investigator.

It is possible to say, with assurance, that the spectrum of fishery indicators used (CPE, species composition, population structure, and population estimates) points to fishery stability over long periods. There is no indication of trend. Rather, there is variability with offsetting rises and falls leaving the

TABLE IX. Age-class distribution and mean lengths (mm) from spring estimates for selected kinds of fishes that were aged from 1977 to 1982.

Age-class	1977 Number Aged	1977 Mean Length*	1978 Number Aged	1978 Mean Length	1979 Number Aged	1979 Mean Length	1980 Number Aged	1980 Mean Length	1981 Number Aged	1981 Mean Length	1982 Number Aged	1982 Mean Length	Total Aged
RIVER CARPSUCKER													
0	0		0		0		0		0		0		0
I	8		1	128	26	134	16	5	56	91	8	167	115
II	23		6	191	26	234	58	186	54	269	16	232	183
III	18		23	252	36	305	13	291	53	357	14	302	157
IV	11		13	321	32	351	35	337	35	391	12	377	138
V	3		7	384	29	404	20	385	13	486	2	427	74
VI	0		3	414	12	427	12	419	6	†	0	0	33
VII	0		1	442	1	401	2	533			0	0	4
TOTAL	63		54		162		156		217		52		704
CARP													
0	0		0		0		0		0		0		0
I	1		0		20	163	12	†	0		1	162	34
II	6		0		52	251	35	285	30	234	1	271	124
III	12		3	285	50	375	60	368	68	540	23	384	216
IV	24		14	389	81	453	48	455	67	436	19	457	253
V	18		11	445	67	518	52	521	68	489	19	426	235
VI	4		11	523	22	582	16	577	22	570	2	556	77
VII	5		5	555	9	609	9	617	4	610	1	664	33
VIII	1		0		0		1	700	2	667	0		4
IX	0		0		1	655	0		0		0		1
TOTAL	71		44		302		233		261		66		977
FRESHWATER DRUM													
0	0		0		11	†	13	†	6	†	0		30
I	1		0		24	147	7	153	9	142	0		41
II	7		1	175	13	274	10	270	9	159	19	237	59
III	19		13	260	35	287	23	311	29	302	8	297	127
IV	6		8	309	54	334	33	332	32	331	6	332	139

TABLE IX. Continued.

Age-class	1977 Number Aged	1977 Mean Length*	1978 Number Aged	1978 Mean Length	1979 Number Aged	1979 Mean Length	1980 Number Aged	1980 Mean Length	1981 Number Aged	1981 Mean Length	1982 Number Aged	1982 Mean Length	Total Aged
V	1		6	361	7	564	9	381	13	382	1	394	37
VI	1		2	381	4	490	3	455	7	440	1	461	18
VII	0		1	467	0		0		1	507	0		2
TOTAL	35		31		148		98		106		35		453
GOLDEYE													
0	0		0		1	†	1		0		0		2
I	2		0		4	199	17	173	13	201	0		36
II	5		3	172	47	222	34	243	26	246	16	252	131
III	25		17	271	55	327	38	288	55	324	18	324	208
IV	3		12	343	41	338	48	345	39	356	11	378	154
V	0		2	374	21	411	13	377	11	383	0		47
VI	0		0		0		3	417	0		0		3
TOTAL	35		34		169		154		144		45		581

*No spring estimate completed in 1977.

†Age-class not represented in spring estimate.

TABLE X. Length-frequency of river carpsucker and freshwater drum collected during population estimates.

Implied Limits (mm)	1978*		1979†		1980†		1981†		1982*	
	Number	Relative Abundance	Number	Relative Abundance	Number	Relative Abundance	Number	Relative Abundance	Number	Relative Abundance
RIVER CARPSUCKER										
100–124	1	1.2	9	2.3	6	1.2	3	0.7	4	3.7
125–149	1	1.2	10	2.5	28	5.7	18	4.2	8	7.3
150–174	3	3.5	14	3.6	41	8.4	23	5.4	13	11.9
175–199	3	3.5	21	5.4	44	9.0	54	12.6	16	14.7
200–224	6	7.1	10	2.6	39	8.0	49	11.5	15	13.8
225–249	7	8.2	10	2.6	41	8.4	26	6.1	7	6.4
250–274	11	12.9	19	4.9	34	6.9	21	9.9	7	6.4
275–299	8	9.4	30	7.7	30	6.1	34	8.0	6	5.5
300–324	4	4.7	33	8.4	19	3.9	37	8.7	7	6.4
325–349	17	20.0	73	18.7	54	11.0	41	9.6	7	6.4
350–374	7	8.2	74	18.9	67	13.7	49	11.5	8	7.3
375–399	12	14.2	60	15.3	54	11.0	45	10.5	7	6.4
400–424	3	3.5	18	4.6	20	4.1	16	3.7	3	2.8
425–449	2	2.4	4	1.0	11	2.2	8	1.9	1	0.9
450–474	0		5	1.3	1	0.2	0		0	
475–499	0		0		0		3	0.8	0	
> 500	0		1	0.3	1	0.2	0		0	
TOTAL	85		396		490		427		109	
FRESHWATER DRUM										
100–124	0		21	10.0	28	10.0	4	2.3	0	
125–149	0		19	9.0	49	17.8	11	6.3	0	
150–174	0		7	3.3	30	10.9	2	1.1	0	
175–199	1	3.1	4	1.9	4	1.4	0		0	
200–224	0		2	1.0	8	2.9	4	2.3	5	8.8
225–249	3	9.1	9	4.3	13	4.7	4	2.3	16	28.1
250–274	10	30.0	9	4.3	8	2.9	2	1.1	8	14.0
275–299	3	9.0	12	5.7	17	6.2	12	6.9	4	7.0
300–324	6	18.2	26	12.4	30	10.9	37	21.1	11	19.3
325–349	4	12.1	50	23.8	28	10.1	38	21.7	6	10.5
350–374	2	6.0	24	11.4	28	10.1	33	18.9	2	3.5
375–399	3	9.1	19	9.0	20	7.2	15	8.6	3	5.3
400–424	0		5	2.4	4	1.4	3	1.6	0	
425–449	0		2	1.0	3	1.1	2	1.1	1	1.7
450–474	1	3.1	0		4	1.4	5	2.9	1	1.7
475–499	0		1	0.5	2	0.7	2	1.1	0	
> 500	0		0		0		1		0	
TOTAL	33		210		276		175		57	

*Includes spring estimate only.

†Includes spring, summer, and fall estimates.

impression of a dynamic system that responds to a variety of environmental cues and stresses and demonstrates compensatory mechanisms.

The relatively stable composition of species (distorted operationally by the appearance of large numbers of flathead catfish) indicates a maintenance of the predator–prey relationships within the fishery (Tables V and VI). Had there been selective removal of either component after plant operation commenced, an altered pattern of species composition would be expected. The absence of such a shift is believed to be evidence of a basic stability.

The average preoperational CPE was 28. Operationally, the CPE was 38. These similar rates, however, were from quite variable seasonal and annual rates. Long-term information must be utilized in contrast to individual seasonal CPE's which reflect the variability of both the actual populations and the effects of environmental conditions upon collection procedures. Seasonal, short-term changes in CPE cannot be utilized to make meaningful judgments concerning the stability of the fish population.

The population–age structure of the Missouri River fishery is difficult to determine. The mean length of a given age-class changes as much as 150 mm from spring to fall and can vary a similar amount in a given season from year to year. This can be influenced by both methodology (variable susceptibility, particularly of the lower age-classes, to collection gear) as well as real changes in growth due to availability of food and related environmental conditions. Length–frequency data for river carpsucker and freshwater drum collected in the population estimate studies are provided (Table X). Although precise designation of age-class is not possible (because only 7 fishes per 25-mm length-category were aged), the length-frequency data do provide an approximation of age-class structure. The data indicate overall long-term stability in the face of short-term fluctuation as previously discussed. These four indicators (CPE, length-frequencies, species composition, and population estimates) are individually valid and are collectively concurrent with the view that maintenance of a stable condition is existent in the fishery population in the vicinity of the Nebraska City station.

Young-of-the-year comprised the vast majority of the impinged population. The mean length of 1,508 impinged fishes was 88 mm. The stability of the fishery is believed traceable to this fact. Members of the breeding population are not impinged in significant numbers. The stability of a fishery in the face of all forms of mortality is dependent upon the compensatory capacity of reproduction. The loss to the fishery of the young-of-the-year impinged at Nebraska City station has not affected the compensatory capacity of the breeding population.

The restricted winter habitat is believed to limit the size and nature of the fish population. Summer flows typically provide relatively extensive spawning and nursery habitats in comparison to a drastically reduced winter habitat (Hesse and Newcomb, 1982). It is our opinion that any young-of-the-year returned alive to the river would not increase the size of the fishery since that is restricted by the overwintering habitat.

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